# The Pulse of Time: Galileo Galilei, the Determination of Longitude, and the Pendulum Clock. Silvio A. Bedini

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Review
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opinion adequately justified the central thesis of his book.

In this first generation of scientists immediately after Galileo, astronomy obviously was to receive little attention. Their interests turned rather to geometry and physics, and specifically to the problems of indivisibles and the composition of the continuum, problems that were beyond the tools available at the time. Segre argues, contrary to Pietro Redondi, that the evidence shows that religion was not the cause of the impasse reached by these scientists; rather, the difficulty was the intrinsic recalcitrance of the problems themselves.

Segre's other main goal is to demythologize the picture of Galileo in the secondary literature. The hagiographic image is traced back to Viviani's biography, which is shown by close textual study to reveal at least as much about biographical standards of that age as it does about Galileo's life and work. Likewise, a lengthy discussion of the twentieth-century dispute over whether Galileo was more of an empiricist or an "a priorist" in his methodology (the former attribution is traced to Viviani, while the latter seems to be closer to Segre's reading of Galileo) concludes that this dispute anachronistically tells us more about contemporary philosophies of science than it does about patterns of thought appropriate to the age of Galileo. Supporting this is Segre's interesting finding that Galileo's followers are just as ambiguous as he is on methodological issues.

This book has some important new things to add, and thus is a welcome complement to the already huge literature on the Galileo case.

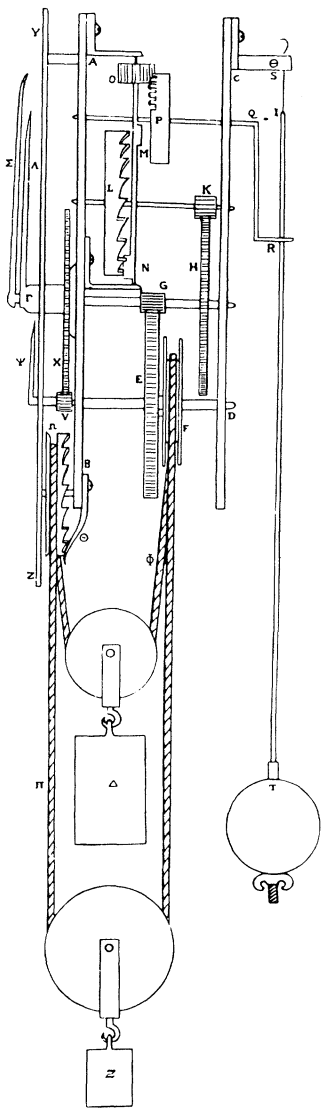
RICHARD J. BLACKWELL

**Silvio A. Bedini.** *The Pulse of Time: Galileo Galilei, the Determination of Longitude, and the Pendulum Clock.* (Biblioteca di Nuncius, Studi e Testi, 3.) xiv + 132 pp., frontis., illus., apps., index. Florence: Leo S. Olschki, 1991. L 40,000 (paper).

The pendulum as a regulator for timekeeping represents by any standards an important stage in the development of precision in the empirical sciences, pure and applied. One cannot say that it would never have been conceived outside the context of the search for reliable methods of finding longitude at sea, but that was one of the most powerful incentives to Galileo. His first conception of a workable scheme dates from 1641–1642; it was the basis of a working device within a decade or so, in Florence. In 1656 or 1657, Christiaan Huygens devised and put into execution an alternative solution. National pride over the priority question still keeps the flame of controversy flickering faintly, but Silvio Bedini shows that he is capable of taking a reasonably distanced view of events and of concentrating on the finer points of this very rich area of study.

The idea of a portable timepiece to enable the measurement of longitude at sea was clearly expressed by Gemma Frisius in 1522. Various others had the same idea, and watches seem even to have been in use for this purpose—perhaps not effectively—before the end of the sixteenth century. The pendulum clock is not, as we can see, particularly well fitted to time measurement at sea, and although it owed its existence to the longitude problem, one can usefully distinguish between motivation and inspiration here. Similarities between the pendulum and its predecessors are fairly obvious, to those who have the advantage of hindsight. Galileo does not—of course—reveal his sources of inspiration. His biographer Vincenzio Viviani, as we all know, claimed that the idea came from Galileo's watching a lamp in the cathedral of Pisa. Bedini turns our attention rather toward Galileo's experiments in music and his well-known use of a pendulum (*pulsilogium*) to determine the pulse rates of patients with fever. The originality of Galileo's device, even the discovery of the isochronism of the pendulum, was subject to dispute almost at once, and that he kept the tune in a very low key suggests that he could see the justice of some of the points being made by his detractors. Just as inevitably, the tempo quickened when rich research contracts with foreign princes were in the wind. His negotiations with the Spaniards and the States General, not to mention some of the details of his inventions, make salutary reading. I like in particular the headgear with telescope attached, leaving one eye free.

Galileo's clockwork devices were the product of the end of his life, and blindness meant that he had to collaborate with his son, and not only on practical problems. Here is one of the chief causes of the obfuscation of history; another is the obvious



*Schematic drawing of the pendulum-regulated clock designed by Christiaan Huygens (reprinted in Bedini,* Pulse of Time *from Huygens,* Horologium*).*

need to keep secrecy on a matter with great financial advantages. Bedini tells the story of the clock, and of subsequent controversy, with verve and simple honesty. He makes useful comparisons with the work of Huygens and goes in some detail into a number of clocks in the Medici collections. (Not least among them was the dragon clock that Cosimo II presented to the emperor of China.) One of the most enjoyable chapters, however, concerns a little-known but important fact: the great public clock of the Palazzo Vecchio in Florence, embodying Galileo's two clockwork inventions (the escapement and the pendulum regulator), by means of which the grand duke planned to standardize time reckoning throughout Tuscany, continues to work without major modification to the present day. In all this, we should not overlook the important part played by the much maligned Viviani, court mathematician and supervisor of the Tuscan project. It is ironic that much of what we know of the earliest history of the clock in the Palazzo Vecchio comes from a drawing that Prince Leopold sent to Ismael Boulliau in 1659 to be forwarded to Huygens. The drawing is still in the Huygens papers at Leiden.

Bedini gives much useful information, not only about the pendulum clocks he discusses, but about their medieval forebears. He includes some excellent illustrations, chapters on Viviani's tables for the standardization of time, and a brief but invaluable survey of the manuscripts relevant to the entire historical episode. Much has been written on this over the centuries, but Bedini's now becomes the most important self-contained account.

J. D. NORTH

**A. Arnauld.** *On True and False Ideas.* Translated, with an introductory essay by **Stephen Gaukroger.** (Classics of Philosophy and Science.) viii + 240 pp., illus., bibl., index. Manchester/New York: Manchester University Press, 1990. $59.95.

Antoine Arnauld's *Traité des vrais and fausses idées* (1683) opened an angry dispute with Nicole Malebranche on the nature of ideas and their function in perceptual cognition that, merged with the question of grace, lasted up to Arnauld's death in 1694. Stephen Gaukroger offers to the English-speaking world a first and accurate version of this important work. In the introductory essay, the editor proficiently describes the philosophical and scientific framework within which the debacle of Aristotelianism and the ambiguities in Descartes's account of perception raised the issue of ideas in the second half of the seventeenth century. Among the causes of the downfall of the Aristotelian explanation